Experimental Investigation on Strength and Durability Parameters of Concrete Replacing Cement by Glass Powder in Concrete with Different Dosages for M25 and M30 Concrete

KOLUSU MARAIAH BABU[1], M. JAYARAM[2]

[1]M.Tech(structural Engineering),Department of Civil Engineering, Vikas Group of Institutions,Nunna,Vijayawada rural,Krishna District,A.P.,India

[2]Assistant Professor (M.Tech), Department of Civil Engineering, Vikas Group of Institutions,Nunna,Vijayawada rural,Krishna District,A.P.,India

ABSTRACT: ***In a growing country like India a huge amount of industrial waste are polluting the environmental. With a view to the above, this study aims at utilization of such industrial by product for value added application. In addition the waste can improve the properties of construction materials. The recycled glass has been used in the form of powder. The glass powder was tested with concrete and mortar. Cement was replaced by the glass powder in the proportion of 0%, 5%, 10%, 15%, 20%, 25%, 30%, 35%, 40%, 45%, 50%, 55% and 60% for M25 grade and M30 grade of concrete with 0.5 and 0.44 water-cement ratios respectively. The compressive strength, split tensile strength, consistency and flexural strength were conducted for the above replacements. The result showed glass powder improves the mechanical properties. The advantages of this project are that the replacement of glass powder is economically cheap as well as a superior concrete can be made.***

INTRODUCTION

Concrete is one of the world's most used construction material due to its versatility, durability and economy. India uses about 7.3 million cubic meters of ready-mixed concrete each year. It finds application in highways, streets, bridges, high-rise buildings, dams etc. Green house gas like CO_2 leads to global warming and it contributes to about 65% of global warming. The global cement industry emits about 7% of green house gas to the atmosphere. To reduce this environmental impact alternative binders are introduced to make concrete.

Concrete is a blend of cement, sand, coarse aggregate and water. The key factor that adds value to concrete is that it can be designed to withstand harshest environments significant role. Today global warming and environmental devastation have become manifest harms in recent years, concern about environmental issues, and a changeover from the mass-waste, mass consumption, mass-production society of the past to a zero-emanation society is now viewed as significant. Normally glass does not harm the environment in any way because it does not give off pollutants, but it can harm humans as well as animals, if not dealt carefully and it is less friendly to environment because it is non-biodegradable. Thus, the development of new technologies has been required.

Glass Powder

- Glass is an amorphous (non-crystalline) that in essence, a super cooled liquid and not a solid. Glass can be made with excellent homogeneity in a variety of forms and sizes from small fibers to meter-sizes pieces.

- Primarily glass is made up of sand, soda ash, limestone and other additives (Iron, Chromium, Alumina, Lead and Cobalt).
- Glass has been used as aggregates in construction of road, building and masonry materials

Source of Glass

- Sand is filtered through three different size screens having three different sizes.
- The finest sand makes the finest glass the largest sand makes the strongest glass.
- Sand is melted in crucible to make glass.

Source of Waste Glass

- Glass food and beverages container.
- Window repair shops
- Glass decorative items
- Old tube lights, electric bulbs
- Glass polishing and glass window and door manufacturing shop

Objective of the project

Experiments were conducted on concrete prepared by partial replacement of cement by waste glass powder of particle size 600 micron and downwards.

The main objective of this investigation was to evaluate the effect of waste glass powder on the compressive strength and the other properties of concrete and to evaluate the possibility of using glass powder in concrete without sacrificing the strength. The following were also considered.

- Partial substitute for the ordinary Portland cement
- To investigate the structural behavior of such replaced concrete components
- To determine the percentage of glass powder which gives maximum strength when compared to control concrete.

LITERATURE REVIEW

Shilpa Raju, Dr. P. R. Kumar presented the global warming is caused by the emission of green house gases, such as CO2, to the atmosphere. Among the greenhouse gases, CO2 contributes about 65% of global warming. The global cement industry contributes about 7% of greenhouse gas emission to the earth's atmosphere. Consequently efforts have been made in the concrete industry to use waste materials as partial replacement of coarse or fine aggregates and cement. Waste glass is one materials when ground to a very fine powder shows pozzolanic properties which can be used as a partial replacement for cement in concrete. In this paper, an attempt has been made to find out the strength of concrete containing waste glass powder as a partial replacement of cement for concrete. Cement replacement by glass powder in the range 5% to 40% increment of 5% has been studied. It was tested for compressive strength and flexural strength at the age of 7, 28 and 90 days and compared with those of conventional concrete. Results showed that replacement of 20% cement by glass powder was found to have higher strength. Also alkalinity test was done to find out resistance to corrosion.

J.M. Khatib, E.M. Negim, H.S. Sohl and N. Chileshe were presented in this paper investigates the performance of concrete containing glass powderas partial substitution of cement. Portland cement (PC) was partially replaced with 0-40% glass powder. Testing included ultrasonic pulse velocity, compressive strength and absorption. Specimens were cured in water at 20°C. The results indicate that

the maximum strength of concrete occurs at around 10% glass powder. Beyond 10% glass powder the strength of concrete reduces and is lower than that of the control.

Using ground glass powder can reduce the use of cement and the associated energy demend and impact on air pollution and CO_2 emission. The slump of concrete seems to increase with the increase in glass powder in the concrete mix. At 10% glass powder content the compressive strength of concrete is higher than that of substantially decreases.

Gunalaan Vasudevan, Seri Ganis Kanapathy pillay were presented in this study was conducted to investigate the effect of using waste glass powder in concrete. Laboratory work was conducted to determine the performance of control sample and concrete with used waste glass powder. The performance of these types of concrete was determined by the workability test, density test and compressive strength test. The workability of concrete is determined using slump test and compacting factor test. Meanwhile, compressive strength test is done to determine the strength of concrete. For each type of concrete, a total of six 150mm x 150mm x 150mm cubes were cast. The cubes were tested at the ages of 7, 14 and 28 days to study the development of compressive strength. The results indicate that the concrete with using waste glass powder were able to increase the workability of concrete and also the compressive strength. However, the density is reduced compare to standard mixture of concrete.

Dhanaraj mohan patil , Dr. Keshav , K.Sangle were explained the concrete is a construction material composed of cement, aggregates (fine and coarse aggregates) water and admixtures. Today many researches are ongoing into the use of Portland cement replacements, using many waste materials like pulverized fly ash (PFA) and ground granulated blast furnace slag (GGBS). Like PFA and GGBS a waste glass powder (GLP) is also used as a binder with partial replacement of cement which take some part of reaction at the time of hydration, also it is act as a filler material. In this study, waste glass powders have been used as replacements to the concrete ingredient i.e. cement and the mechanical properties like compressive strength are measured. Also we were studied the size effect of glass powder on strength of concrete. For checking strength effect of replacement of cement by glass powder, the cement is replaced at 10%, 20% and 30%. For study of size effect of glass powder the powder is divided in to two grades one is glass powder having size less than 90 micron and another is glass powder having particle size ranges from 90 micron to 150 micron. It is found from study, Initial strength gain is very less due to addition of GLP on 7th day but it increases on the 28th day. It is found that 20% addition of GLP gives higher strength. And also GLP size less than 90 micron is very effective in enhancement of strength.

MIX DESIGN

Final Quantities of all materials for M25 grade of concrete

Material	Cement	Glass powder	FA	CA	Water	admixture
Proportion	1	-	1	2	0.5	1% of cement
Quantities	4 bags	80kgs	270kgs	540kgs	135liters	2.66liters

Final Quantities of all materials for M30 grade of concrete

Material	Cement	Glass powder	FA	CA	Water	admixture
Proportion	1	-	1.58	2.23	0.44	1% of cement
Quantities	3bags	67kgs	350kgs	495kgs	98liters	2.22liters

MATERIALS AND PROPERTIES

Basically concrete is a versatile engineering material which can be mould in to wide verities of shapes when in wet condition. Concrete is a mixture of cement, fine aggregates, coarse aggregates, water, and admixture (if any). The red mud concrete is a mixture of cement, fine aggregates, coarse aggregates, water.

Cement

Cement is one of the binding materials in this project. Cement is the important building material in today's construction world 53 grade Ordinary Portland Cement (OPC) conforming to ([17] IS: 8112-1989). Table 3.1 gives the properties of cement used.

Cement is a binder, a substance used in construction that sets and hardens and can bind other materials together. The most important types of cement are used as a component in the production of mortar in masonry, and of concrete, which is a combination of cement and an aggregate to form a strong building material.

Cements used in construction can be characterized as being either hydraulic or non-hydraulic, depending upon the ability of the cement to set in the presence of water (see hydraulic and non-hydraulic lime plaster).

Non-hydraulic cement will not set in wet conditions or underwater; rather, it sets as it dries and reacts with carbon dioxide in the air. It can be attacked by some aggressive chemicals after setting.

The chemical reaction results in mineral hydrates that are not very water-soluble and so are quite durable in water and safe from chemical attack. This allows setting in wet condition or underwater and further protects the hardened material from chemical attack.

Cement

Fine aggregate

It is the aggregate most of which passes 4.75 mm IS sieve and contains only so much coarser as is permitted by specification. According to source fine aggregate may be described as:

1. **Natural Sand**– it is the aggregate resulting from the natural disintegration of rock and which has been deposited by streams or glacial agencies
2. **Crushed Stone Sand**– it is the fine aggregate produced by crushing hard stone.
3. **Crushed Gravel Sand**– it is the fine aggregate produced by crushing natural gravel.

According to size the fine aggregate may be described as coarse sand, medium sand and fine sand. IS specifications classify the fine aggregate into four types according to its grading as fine aggregate of grading Zone-1 to grading Zone-4. The four grading zones

Crushed aggregate is a maximum size of 20 mm and normal grading. The specific gravity of the coarse aggregates of 2.73 was used. The sieve analysis of coarse and fine aggregates is confirmed to IS10262.

Fine aggregate

Become progressively finer from grading Zone-1 to grading Zone-4. 90% to 100% of the fine aggregate passes 4.75 mm IS sieve and 0 to 15% passes 150 micron IS sieve depending upon its grading zone.

Coarse aggregate:

It is the aggregate most of which is retained on 4.75 mm IS sieve and contains only so much finer material as is permitted by specification. According to source, coarse aggregate may be described as:

1. **Uncrushed Gravel or Stone**– it results from natural disintegration of rock
2. **Crushed Gravel or Stone**– it results from crushing of gravel or hard stone.
3. **Partially Crushed Gravel or Stone**– it is a product of the blending of the above two aggregate.

According to size coarse aggregate is described as graded aggregate of its nominal size i.e. 40 mm, 20 mm, 16 mm and 12.5 mm etc. for example a graded aggregate of nominal size 20 mm means an aggregate most of which passes 20 mm IS sieve.

A coarse aggregate which has the sizes of particles mainly belonging to a single sieve size is known as single size aggregate. For example 20 mm single size aggregate mean an aggregate most of which passes 20 mm IS sieve and its major portion is retained on 10 mm IS sieve.

Coarse aggregates

GLASS POWDER:

Glass is an amorphous & transparent material, which is super-cooled liquid and not a solid. Glass can be made verity of forms and sizes from small fiber to meter-sizes pieces. Primarily glass is produced by melting a mixture of materials such as silica, CaCO3, and soda ash at high temperature followed by cooling during which solidification occurs without

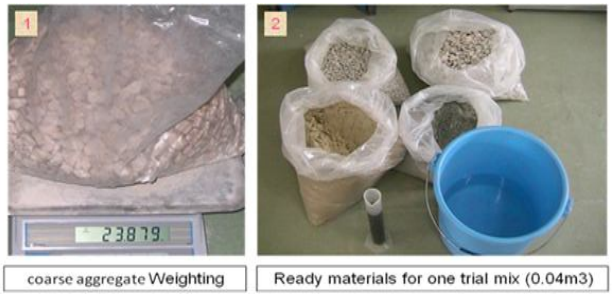
crystallization. Glass has been used as aggregates in road construction, masonry and building materials. Before adding glass powder in the concrete it has to be powdered to wanted size. Glass powder is obtained from Crushing of glass Pieces. A Glass powder can be used as cement replacement material upto particle size less than 90µm.

Glass powder

CONCRETE SPECIMENS MAKING

Preparation of Materials

All the materials were proportioned by weight to give the required ratios of water to cement (w/c)



Materials weighting

Mixing Process

The mixing process was done using an electrically operated concrete mixer of 0.04 m3 capacity. The concrete making and mixing in the laboratory was done with accordance to ASTMC-192. The batching procedure was as follows:

1) Add coarse, fine aggregate mixing for about 2-3 minutes.
2) Add cement than mixing for about 1-2 minutes.
3) Add approximately two-thirds of water slowly and mix for 2-3minutes.
4) Add fiber with water than mixing for 2-3 minutes.

Materials mixing process

Test to be conducted on the specimens:

Compressive strength

- 7 days specimens age
- 28 days specimens age

Split tensile strength of specimens

- 28 days specimens age

Flexural strength of specimens

- 28 days specimens age

Durability tests

- Acid attack test
- Alkaline attack test
- Sulphate attack test

RESULTS AND ANALYSIS

1. Cement

Test results for cement

Sl. No	Test	Results	IS code used	Acceptable limit
1	Specific gravity of cement	3.150	IS:2386:1963	3 to 3.2
2	Standard consistency of cement	6mm at 34% w/c	IS:4031:1996	w/c ratio 28%-35%
3	Initial and final setting time	50mins and 10 hours	IS:4031:1988	Minimum 30mins and should not more than 10 hours
4	Fineness of cement	3.48%	IS:4031:1988	<10%

2. COARSE AGGREGATES

Sl. No	Test	Results	Is code used	Acceptable limit
1	Fineness modulus	6.5	IS:2386:1963	6.0 to 8.0mm
2	Specific gravity	2.90	IS:2386:1963	2 to 3.1mm
3	Porosity	46.83%	IS:2386:1963	Not greater than 100%
4	Voids ratio	0.8855	IS:2386:1963	Any value
5	Bulk density	1.50g/cc	IS:2386:1963	-
6	Aggregate impact value	37.5	IS:2386:1963	Less than 45%
7	Aggregate crushing	26.6%	IS:2386:1963	Less than 45%

3. FINE AGGREGATES

Sl. No	Test	Result	Is code used	Acceptable limits
1	Fineness modulus	4.305	IS:2386:1963	Not more than 3.2 mm
2	Specific gravity	2.43	IS:2386:1963	2.0 to 3.1
3	Porosity	36.6%	IS:2386:1963	Not greater than 100%
4	Voids ratio	0.577	IS:2386:1963	Any value
5	Bulk density	1.5424	IS:2386:1963	-
6	Bulking of sand	3.0%	IS:2386:1963	Less than 10%

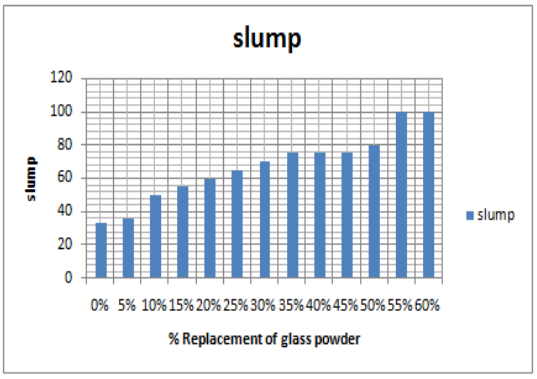
I TESTS ON CONCRETE

FREST CONCRETE TESTS

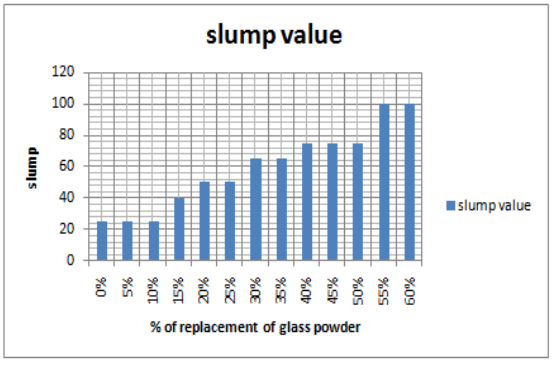
1. Slump cone test

Sl. No	% of replacement of glass powder	Slump value for M25 grade concrete	Slump value for M30 grade concrete
1	0%	33	25
2	5%	36	25
3	10%	50	25
4	15%	55	40
5	20%	60	50
6	25%	65	50
7	30%	70	65
8	35%	75	65
9	40%	75	75
10	45%	75	75
11	50%	80	75
12	55%	100	100
13	60%	100	100

Graph: For M25 grade concrete



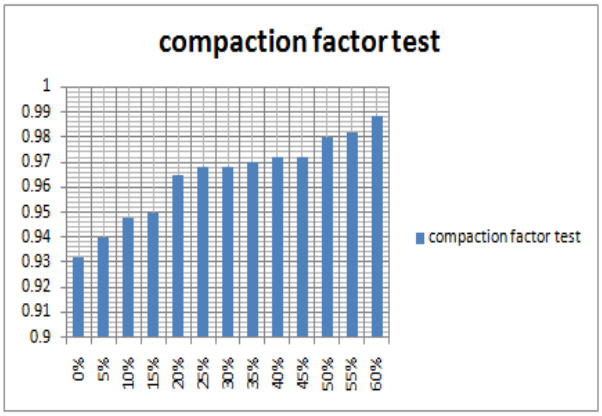
Graph: For M30 grade concrete



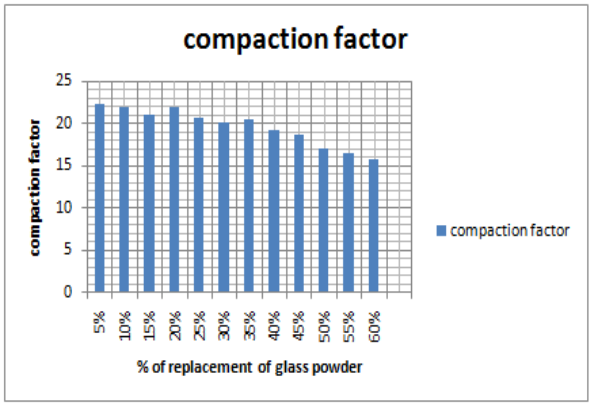
2. Compaction factor test

s. no	% of replacement of glass powder	Compaction factor test for M25 grade concrete	Compaction factor test for M30 grade concrete
1	0%	0.932	0.862
2	5%	0.940	0.874
3	10%	0.948	0.896
4	15%	0.950	0.920
5	20%	0.965	0.90
6	25%	0.968	0.94
7	30%	0.968	0.960
8	35%	0.97	0.972
9	40%	0.972	0.986
10	45%	0.972	0.976
11	50%	0.980	0.980
12	55%	0.982	0.984
13	60%	0.988	0.99

Graph: For M25 grade concrete



Graph: For M30 grade concrete

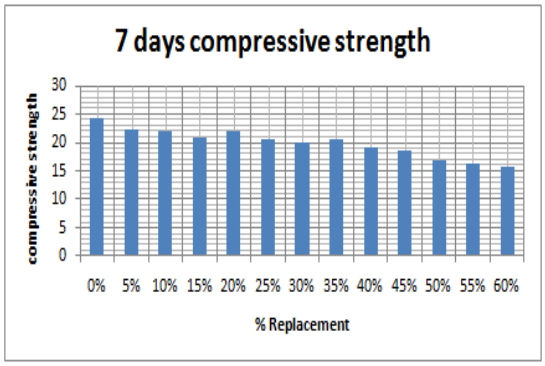


TESTS ON HARDENED CONCRETE

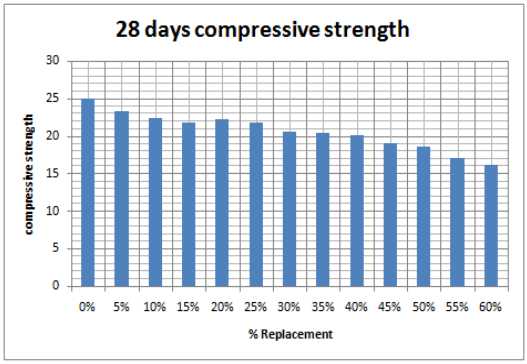
COMPRESSIVE STRENGTH OF CONCRETE

Sl. No	% replacement	Compressive strength of concrete for M25 grade concrete		Compressive strength of concrete for M30 grade concrete	
		7days	28days	7 days	28days
1	0%	24.30	24.98	29.40	29.96
2	5%	22.36	23.24	27.46	28.34
3	10%	21.98	22.40	26.84	27.60
4	15%	21.00	21.80	26	26.40
5	20%	21.90	22.20	26.20	26.90
6	25%	20.60	21.80	24.80	25.60
7	30%	20.10	20.60	24.20	25.20
8	35%	20.48	20.40	24.60	24.80
9	40%	19.20	20.10	23.10	24.20
10	45%	18.60	19.10	22.80	23.10
11	50%	16.98	18.60	21.00	22.50
12	55%	16.40	17.00	20.60	21.20
13	60%	15.80	16.20	20.20	20.30

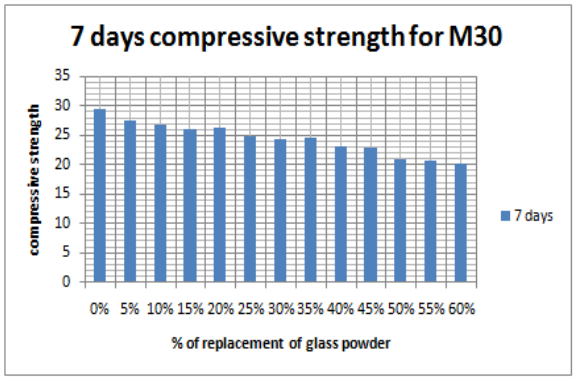
Graph: 7 days compressive strength of concrete for M25 grade concrete



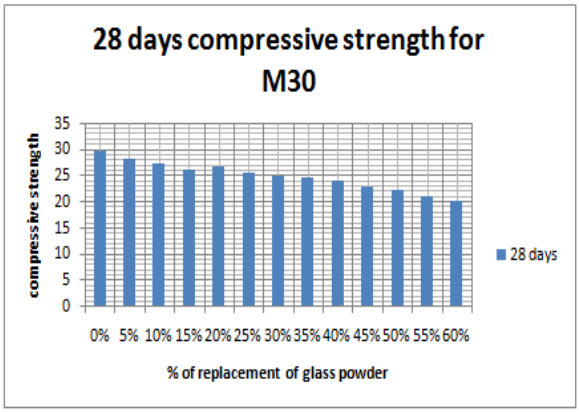
Graph: 28 days compressive strength of concrete for M25 grade concrete



Graph: 7 days compressive strength of concrete for M30 grade concrete



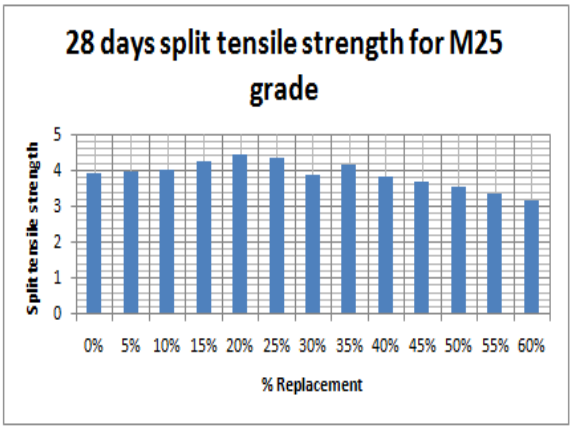
Graph: 28 days compressive strength of concrete for M30 grade concrete



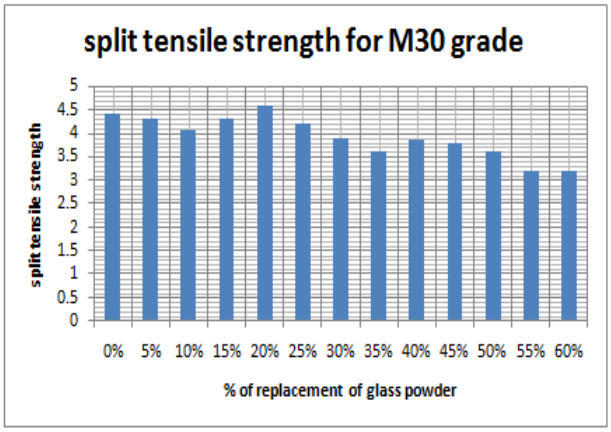
SPLIT TENSILE STRENGTH OF CONCRETE

Sl. No	% Replacement of glass powder	28 days Split tensile strength for M25 grade concrete	28 days Split tensile strength for M30 grade concrete
1	0%	3.93	4.40
2	5%	3.98	4.30
3	10%	4.04	4.06
4	15%	4.30	4.30
5	20%	4.49	4.60
6	25%	4.40	4.20
7	30%	3.91	3.88
8	35%	4.20	3.60
9	40%	3.84	3.84
10	45%	3.70	3.80
11	50%	3.56	3.60
12	55%	3.40	3.20
13	60%	3.20	3.20

Graph: split tensile strength for M25 grade concrete



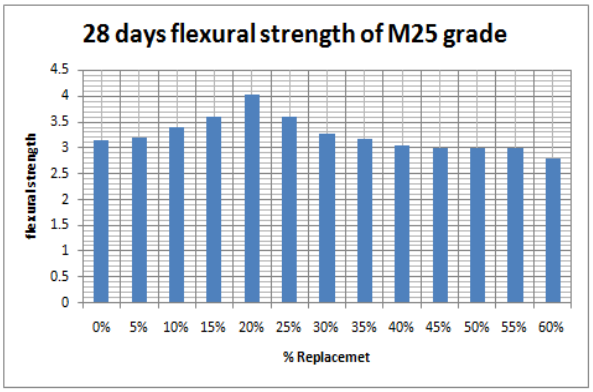
Graph: split tensile strength for M30 grade concrete



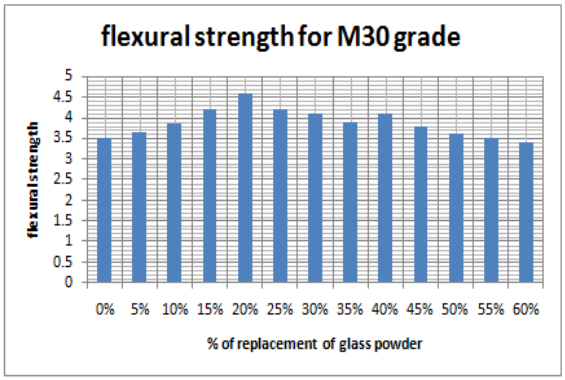
FLEXURAL STRENGTH OF CONCRETE

s. no	% Replacement of glass powder	28 days Flexural strength For M25 grade concrete	28 days flexural strength for M30 grade concrete
1	0%	3.15	3.50
2	5%	3.20	3.65
3	10%	3.39	3.85
4	15%	3.60	4.20
5	20%	4.01	4.60
6	25%	3.60	4.20
7	30%	3.26	4.10
8	35%	3.16	3.90
9	40%	3.04	4.10
10	45%	3.00	3.80
11	50%	2.98	3.60
12	55%	3.00	3.50
13	60%	2.80	3.40

Graph: Flexural strength of concrete for M25 grade



Graph: Flexural strength of concrete for M30 grade

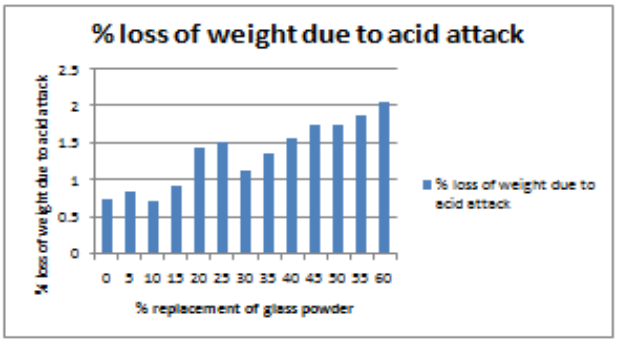


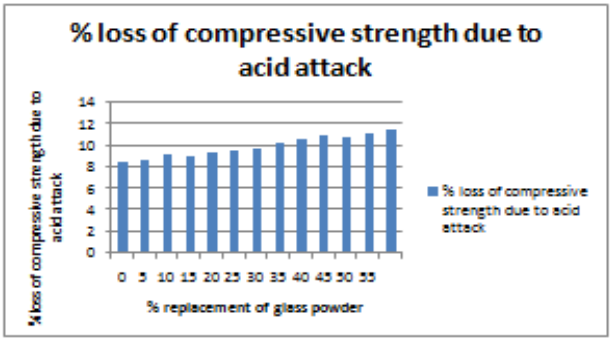
DURABILITY

FOR M25 GRADE CONCRETE

1. Acid attack test

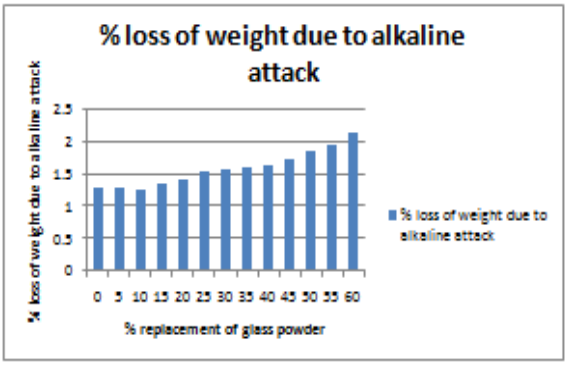
Sl. No	% replacement of glass powder	Initial weight of cube after 28days curing in grams	Final weight of cubes after 90days curing in grams	% loss of weight due to acid attack	Compressive strength of cube after 28days curing	Compressive strength of cubes after 90days curing	% loss of compressive strength due to acid attack
1	0	2291	2274	0.74	24.98	22.84	8.56
2	5	2320	2300	0.86	23.24	21.23	8.64
3	10	2251	2235	0.71	22.40	20.34	9.20
4	15	2334	2312	0.94	21.80	19.82	9.08
5	20	2291	2258	1.44	22.20	20.13	9.32
6	25	2285	2250	1.53	21.80	19.70	9.63
7	30	2274	2248	1.14	20.60	18.58	9.80
8	35	2352	2320	1.36	20.40	18.30	10.29
9	40	2296	2260	1.56	20.10	17.97	10.60
10	45	2300	2260	1.74	19.10	17.00	10.99
11	50	2296	2256	1.742	18.60	16.60	10.75
12	55	2333	2289	1.88	17.00	15.10	11.17
13	60	2322	2274	2.06	16.20	14.33	11.54

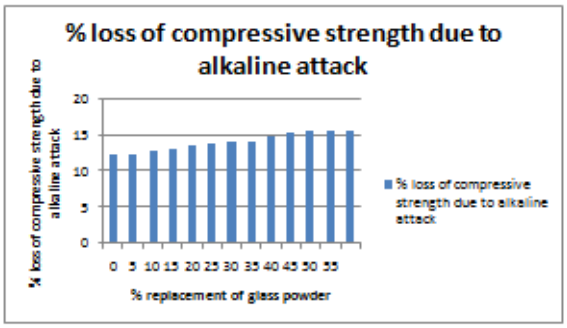




2. Alkaline attack test

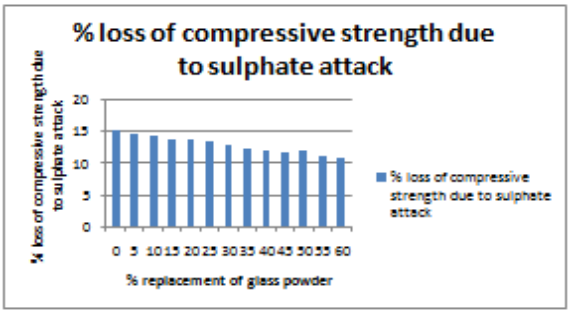
Sl. No	% replacement of glass powder	Initial weight of cube after 28days curing in grams	Final weight of cubes after 90days curing in grams	% loss of weight due to alkaline attack	Compressive strength of cube after 28days curing	Compressive strength of cubes after 90days curing	% loss of compressive strength due to alkaline attack
1	0	2320	2350	1.29	24.98	21.90	12.32
2	5	2285	2255	1.31	23.24	20.34	12.47
3	10	2274	2245	1.27	22.40	19.53	12.81
4	15	2296	2265	1.35	21.80	18.92	13.21
5	20	2320	2287	1.42	22.20	19.18	13.60
6	25	2444	2406	1.55	21.80	18.77	13.90
7	30	2286	2250	1.57	20.60	17.67	14.22
8	35	2340	2302	1.62	20.40	17.52	14.11
9	40	2280	2242	1.66	20.10	17.12	14.82
10	45	2310	2270	1.73	19.10	16.17	15.34
11	50	2296	2253	1.87	18.60	15.66	15.80
12	55	2352	2306	1.95	17.00	14.35	15.58
13	60	2334	2284	2.14	16.20	13.64	15.80





3. Sulphate attack test

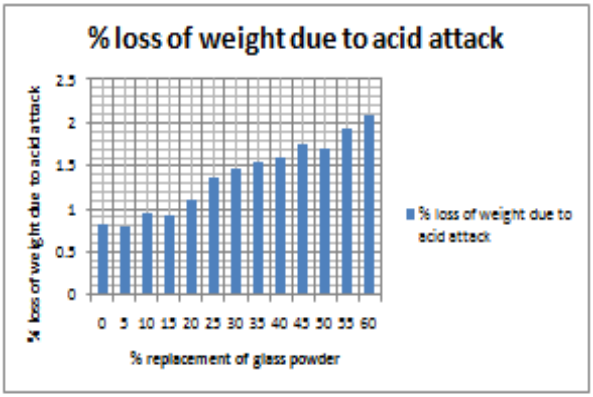
Sl. No	% replacement of glass powder	Compressive strength of cube after 28days curing	Compressive strength of cubes after 90days curing	% loss of compressive strength due to sulphate attack
1	0	24.98	21.18	15.21
2	5	23.24	19.85	14.58
3	10	22.40	19.17	14.41
4	15	21.80	18.80	13.76
5	20	22.20	19.10	13.96
6	25	21.80	18.85	13.53
7	30	20.60	17.96	12.81
8	35	20.40	17.87	12.40
9	40	20.10	17.70	11.94
10	45	19.10	16.88	11.62
11	50	18.60	16.33	12.20
12	55	17.00	15.10	11.17
13	60	16.20	14.45	10.80

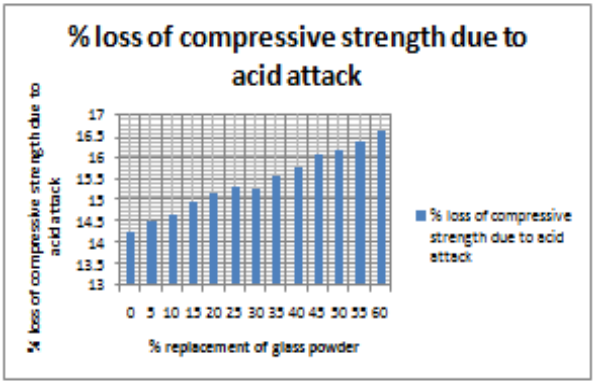


For M30 grade concrete:

1. Acid attack test

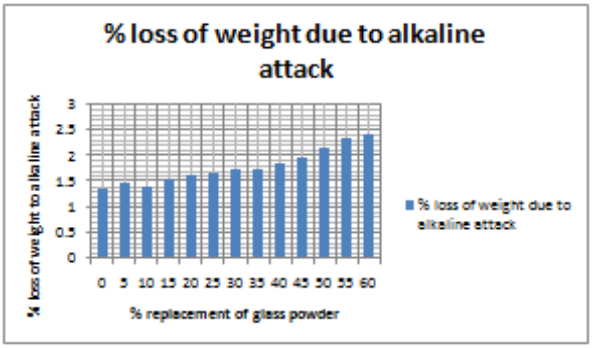
Sl. No	% replacement of glass powder	Initial weight of cube after 28days curing in grams	Final weight of cubes after 90days curing in grams	% loss of weight due to acid attack	Compressive strength of cube after 28days curing	Compressive strength of cubes after 90days curing	% loss of compressive strength due to acid attack
1	0	2295	2276	0.83	29.96	25.96	13.35
2	5	2420	2400	0.82	28.34	24.50	13.55
3	10	2354	2331	0.97	27.60	23.78	13.84
4	15	2235	2214	0.94	26.40	22.65	14.20
5	20	2291	2265	1.13	26.90	22.97	14.60
6	25	2385	2352	1.38	25.60	21.71	15.20
7	30	2374	2339	1.48	25.20	21.26	15.64
8	35	2322	2286	1.55	24.80	20.84	15.96
9	40	2296	2259	1.61	24.20	20.25	16.32
10	45	2300	2259	1.78	23.10	19.311	16.40
11	50	2322	2282	1.72	22.50	18.72	16.80
12	55	2344	2298	1.96	21.20	17.54	17.24
13	60	2320	2271	2.11	20.30	16.67	17.86

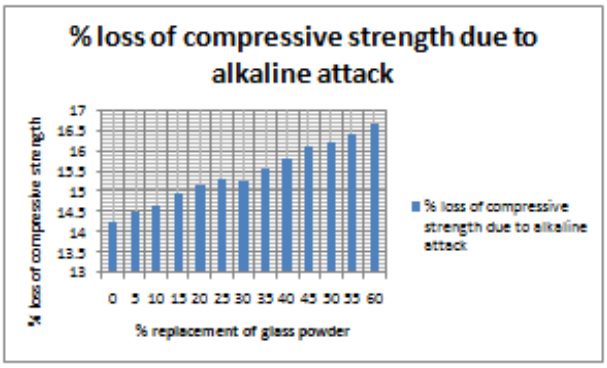




2. Alkaline attack test

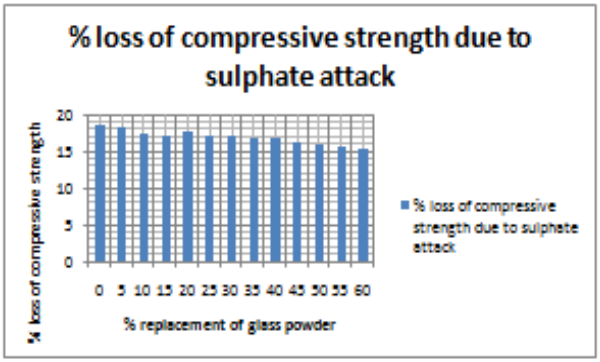
Sl. No	% replacement of glass powder	Initial weight of cube after 28days curing in grams	Final weight of cubes after 90days curing in grams	% loss of weight due to alkaline attack	Compressive strength of cube after 28days curing	Compressive strength of cubes after 90days curing	% loss of compressive strength due to alkaline attack
1	0	2325	2293	1.36	29.96	25.69	14.26
2	5	2375	2340	1.48	28.34	24.22	14.54
3	10	2284	2251	1.42	27.60	23.55	14.68
4	15	2396	2359	1.54	26.40	22.45	14.96
5	20	2320	2282	1.62	26.90	22.81	15.20
6	25	2354	2315	1.68	25.60	21.67	15.34
7	30	2296	2256	1.74	25.20	21.35	15.28
8	35	2320	2280	1.74	24.80	20.93	15.60
9	40	2290	2247	1.86	24.20	20.36	15.84
10	45	2340	2294	1.96	23.10	19.38	16.12
11	50	2396	2344	2.16	22.50	18.84	16.24
12	55	2352	2297	2.34	21.20	17.71	16.46
13	60	2358	2300	2.42	20.30	16.91	16.68





3. Sulphate attack test

Sl. No	% replacement of glass powder	Compressive strength of cube after 28days curing	Compressive strength of cubes after 90days curing	% loss of compressive strength due to sulphate attack
1	0	29.96	24.31	18.86
2	5	28.34	23.12	18.42
3	10	27.60	22.72	17.68
4	15	26.40	21.80	17.42
5	20	26.90	22.12	17.77
6	25	25.60	21.16	17.34
7	30	25.20	20.86	17.22
8	35	24.80	20.58	17.00
9	40	24.20	20.11	16.90
10	45	23.10	19.30	16.45
11	50	22.50	18.85	16.22
12	55	21.20	17.85	15.80
13	60	20.30	17.17	15.42



CONCLUSION

The following conclusions are made based on the above study:

i. The material properties of the cement, coarse aggregates, and fine aggregates are within the acceptable limits hence theses materials are suitable for the research.

ii. The optimum value of compressive split tensile and flexural strength of concrete was observed at 20% replacement of cement by glass powder.

iii. The slump of concrete increases monotonically as the replacement cement with glass powder increases. The workability decreases when cement is replaced partially with glass powder

iv. The present study shows that there is a great potential for the utilization of glass powdering concrete as partial replacement of cement. About 20% of cement may be replaced with glass powder without any sacrifice on the compressive strength

v. Further investigation can be done by using plasticizers to improve the workability and strength. Also durability investigations can be done in see the long term effect of glass powder replacement.

vi. From the analysis and discussion, we are clearly understood that the objectives of this study are achieved. The objectives of the research are:

a) The main purpose of this research is to check the compressive strength of the concrete using the waste glass powder.

b) To check the workability of the concrete using the waste glass powder.

vii. Considering the strength criteria, the replacement of cement by glass powder is feasible. Therefore we can conclude that the utilization of waste glass powder in concrete as cement replacement is possible.

viii. Very finely ground glass has been shown to be excellent filler and may have sufficient pozzolonic properties to serve as partial cement replacement, the effect of ASR

appear to be reduced with finer glass particles, with replacement level.

ix. The durability results of weight loss and strength loss for acid attack and alkaline attack increases with increase in the percentage of glass powder where as in case of sulphate attack the strength is decreases with increase in the percentage of glass powder.

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AUTHOR'S PROFILE:

Mr. KOLUSU MARAIAH BABU was born in Naguluru, Reddigudem Mandal, Krishna (District) AP on July 04,1992. He graduated from the VIKAS COLLEGE OF ENGINEERING AND TECHNOLOGY, NUNNA His special fields of interest included concrete technology ,reinforced concrete structures in Structural Engineering. Presently he is studying M.Tech in Vikas Group of Institutions, Nunna, Vijayawada rural, Krishna District, Andhra Pradesh.

Mr. M. JAYARAM was born in Bhadrachalam, Telangana on October 17 1991. He post graduated from the Velagapudi Ramakrishna Siddhartha Engineering College, Vijayawada. Presently He is working as a Asst Prof in Vikas Group of institutions, Nunna. So far he is having 2 Years of Teaching Experience. His special fields of interest included concrete technology, special concretes, prestresseed concrete, high performance concrete.